10 Handling and Transport of Cattle and Pigs in South America

Mateus J.R. Paranhos da Costa^{1*}, Stella M. Huertas² and Carmen Gallo³

¹Grupo ETCO (Grupo de Estudos e Pesquisas em Etologia e Ecologia Animal) Department de Zootechnia, Facultad de Ciancias Agrarias e Veterinarias, UNSEP (Universidad de Estadual Paulista Julio de Mesquita Filho), São Paulo,Brazil; ²Facultad de Veterinaria, Universidad de la Republica, Montevideo, Uruguay; ³Instituto de Ciencia Animal, Facultad de Ciencias Veterinarias, Universidad Austral de Chile

Summary

This chapter offers a short description of the importance of livestock production chains for South American countries, and covers initiatives used in Brazil, Chile and Uruguay to reduce bruising and other damage to beef and pork carcasses. It is shown that after training truck drivers and handlers, and improving facilities and equipment, the percentage of damaged carcasses was halved. The results also showed that when cattle passed through markets on the way to slaughter they had four times the risk of having meat of a high pH (>5.8) compared with cattle that were shipped direct. Another advantage of the adoption of low-stress handling methods is less stress on the stock people. When better methods are used for handling cattle, corrals can be built from less expensive and more economical materials; this section also provides details of a low-cost corral layout, showing that solid fences that block the animal's vision can be constructed from vertical bamboo strips attached to a wire or wood plank fence. The second section covers extensive new handling research with Nellore cattle, which are more reactive than the British and European breeds. The six tips for handling Nellore are: (i) No shouting or hitting; (ii) Move them through the race before procedures; (iii) Only one animal in the race at a time; (iv) Small groups brought to the corrals; (v) Cows immediately exit to pasture after procedures; (vi) Use a lead horse in the pasture. The third and fourth sections cover new research in Chile and Uruguay with the British and European breeds.

Keywords: bruises, corrals, electric prods, loading trucks, stunning, welfare

Introduction

Farming activities are a major contributor to the economy of South American countries (Duff and Padilla, 2015). In this sector, meat production has a prominent role, particularly the production of beef, poultry and pork (FAO, 2009; Rioja-Scott, 2017). In order to supply both internal and external markets, a huge number of farm animals are handled, transported and slaughtered every year. In the past, most of these activities were carried out with little consideration for the welfare of the animals.

A series of research and extension initiatives have now been carried out in Latin American countries. Several surveys have been conducted in different countries that aimed to identify the main problems faced by farm animals during handling and transport. Based on the results of these surveys, strategies have been developed to implement good animal welfare practices in the field, including the development of guidelines for these good animal welfare practices in Brazil (http://www.grupoetco.org.br/downloads. html, https://www.embrapa.br/suinos-e-aves/bes/

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^{*}Contact e-mail address: mparanhosdacosta@gmail.com

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embarque-e-transporte); Chile (http://www. bienestaranimal.cl/material-difusion) and Uruguay (http://www.bienestaranimal.org.uy/documentos. html). Additionally, the work developed since 2009 by the World Animal Health Organisation (OIE) through the Collaborating Centre for Animal Welfare Chile-Uruguay, with the addition of Mexico in 2013, has disseminated a series of good livestock handling practices recommendations through the development of training courses and practical material for improving the welfare of farm animals under regional production systems (Huertas et al., 2014). Moreover, there has been great progress in many Latin American countries in terms of adopting the OIE standards through the implementation of new legislation (Gallo and Tadich, 2018).

These initiatives have also promoted the adoption of animal welfare standards in existing quality assurance schemes. Good practices of animal welfare are now considered an important component in all production meat chains, covering all the stakeholders (farmers, transporters and slaughterhouse workers). A good example is the initiative launched by the Brazilian Ministry of Agriculture, Livestock and Food Supply to promote pig welfare (MAPA, 2018). It was embraced by most of the leading companies in the Brazilian pig production chain, and it is characterized by the adoption of collective (group) gestation systems (ABCS, 2014; Dias et al., 2015). Nevertheless, the emphasis on the relationship between good animal welfare status and good meat quality is still a key feature for making improvements in animal welfare and handling procedures in Latin America (Paranhos da Costa et al., 2012).

The main strategy has been the production of local applied research to support the new South American regulations on welfare in farm animals, as well as training farmers, transporters, slaughterhouse workers and other animal handlers involved in the food producing chain (Gallo *et al.*, 2010). In this chapter, the different strategies that have been implemented in Brazil, Chile and Uruguay to improve the welfare of the animals and the quality of meat are reviewed.

Carcass Bruises and Skin Lesions as Indicators of Animal Welfare in South America

Carcass bruises are indicators of suboptimal welfare conditions during transport and pre-slaughter practices. Several actions have been developed in some South American countries to address the effects of cattle and pig transport and handling on carcass and meat quality (Paranhos da Costa *et al.*, 2012). The major aim is the reduction of bruises in cattle carcasses and skin lesions in pigs.

Surveys run in Brazil, Chile and Uruguay with cattle (Paranhos da Costa et al., 1998; Gallo et al., 1999; Strappini et al., 2008, 2010; Huertas et al., 2015) and with pigs in Brazil (Dalla Costa et al., 2007, 2009, 2016 and 2017; Jacinto, 2017) have shown that a high percentage of slaughtered cattle and pigs suffered with bruises and skin lesions, respectively. In Brazil, for example, the percentages of cattle carcasses with bruises reached 84.2% in the Pantanal region of the state of Mato Grosso do Sul (Andrade et al., 2009), 92.1% in the state of Minas Gerais (Andrade and Coelho, 2010), 62.2% and 83.8% for entire males and cows assessed in the state of São Paulo (Pellechia, 2014), and 75.7% in the Federal District (Cruz, 2017). The lowest percentage of cattle carcasses with bruises was reported by Mendonça et al. (2017) in a survey conducted in the state of Rio Grande do Sul. There were bruises in 40.0% and 56,7% of males and females carcasses, respectively. Some of these authors identified that the most frequent causes of cattle carcass bruising was long-distance transport and poor handling practices at various stages of the pre-slaughter procedures.

The frequency of skin lesions on Brazilian pigs was also usually high. As shown by Dalla Costa et al. (2009 and 2016) the occurrence of skin lesions increased progressively throughout the preslaughter process and affected more than 90% of the animals when assessment was carried out just before slaughter. The authors described the injuries as associated with management procedures, such as the position of the animal inside a truck compartment and the duration of pre-slaughter fasting. A similar situation was also reported by Jacinto (2017). Most of the pigs (73%) had skin lesions. The causes of the lesions were poor handling procedures (45%), fights (28%) or a combination of both (27%). However, the results from Dalla Costa et al. (2017) showed a large reduction in the percentage of pigs presenting skin lesions just before slaughter. The authors concluded that lesions dropped to 62% due to improvements achieved by adoption of good handling practices during loading, transportation, unloading and reduction of fighting in lairage The use of air-ride suspension improved carcass quality (Dalla Costa et al., 2017).

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In Uruguay, training programmes and the distribution of guidelines through the cattle production chain have been carried out since 2004 (www. bienestaranimal.org.uy). It is now possible to assess the effectiveness of these initiatives by comparing meat quality audits conducted in Uruguay (INIA, INAC and Colorado State University, 2003; INIA, 2017; INIA and INAC, 2009; Brito et al., 2017) on the beef production chain. According to these audits, there was an impressive reduction in the percentage of carcasses with bruises (from 60.4% to 31.8%) between the first and second audit. Unfortunately, in the third audit there was a large increase in the number of bruised carcasses and they reached 72.9% of the slaughtered animals (INIA, 2017). This increase triggers a warning light, since the improvements achieved during the period between the first and second audits was probably lost. People did not continue to use the lessons from the training programmes and the animal welfare recommendations when handling cattle. In the future, preventing deterioration of handling practices will require a continuous programme of both training and supervision of transporters and abattoir workers.

There are, however, in the three countries initiatives aiming to reduce handling problems during pre-slaughter procedures (MAPA, 2016, 2018; SAG, 2018). Independent of the country, commercial systems that include several intermediaries, prolonged transportation and long waiting times under fasting conditions clearly result in even greater prevalence of carcass bruising, skin lesions, meat colour problems and unsuitable pH of the meat (Paranhos da Costa *et al.*, 2012).

Update on Brazilian Research on Cattle Handling Methods

The next part of this chapter is divided into three sections. The first section will cover Brazilian research conducted by the research group led by Mateus Paranhos de Costa. The second and third sections will cover research in Chile and Uruguay conducted by Carmen Gallo's and Stella M. Huertas's research groups. This work mainly covers the *Bos taurus* British and European breeds of cattle that are raised in these areas.

During his extensive work on Brazilian ranches with Nellore cattle, Paranhos de Costa developed five basic handling principles. They are designed to prevent the more excitable, fearful Nellore cattle from becoming agitated during handling. Good handling practices reduce the risk of accidents to both people and cattle.

Cattle handling guidelines for Nellore cattle

Principle 1: Eliminate shouting, hitting, dogs, mixing of groups and electric prods. Figure 10.1 shows that bruising was cut in half when handling was improved (Paranhos da Costa *et al.*, 2008). Use flags to drive animals during handling. Flags should be used to guide animals and not to be constantly waved. Improved handling reduced cortisol levels (Lima *et al.*, 2018).

Principle 2: To prevent excitable Nellore cattle from becoming stressed, only 100 cows are brought near the corrals at a time. A further procedure to



Fig. 10.1. Means (\pm SD) of bruises per carcass of beef cattle according to the type of management adopted for cattle loading at a farm in the state of São Paulo. Treatment 1 = routine farm management; Treatment 2 = routine farm management but without using electric prods; and Treatment 2 = good handling practices including no shouting, no electric prodding or hitting, and no mixing of groups of animals. (Adapted from Parnahos da Costa *et al.*, 2008)

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keep the animals calm is that only 25 cattle at a time are brought into the active working area.

Principle 3: Before doing procedures, all cattle are moved once through the races every time they are handled. A further procedure to prevent agitation caused by waiting in the single-file race (chute) is that only one animal is put in the race at a time. A flag is used to quietly guide each animal out of the crowd pen.

Principle 4: When the cows exit the race after having vaccinations or other procedures they immediately move to the pasture. They exit through a pen where they are rewarded with feed. They are not held in a post-working pen close to the handling facility. They are free to leave after they have eaten some of the reward feed.

Principle 5: When the Nellore cattle are moved through pasture alleys or brought in and out of a pasture, a lead horse is used (Fig. 10.2). Doing this provides better control of cattle driving.

Improved Stockperson Welfare on the Farm

There are scientific publications reporting the results achieved by initiatives to promote animal welfare on farms (ranches) in South America. Nonetheless, there are many examples, collected from livestock people, that show the advantages of adopting good cattle handling practices. For instance, in the year 2000, one of the authors started working in a beef cattle farm at Três Lagoas (Mato Grosso do Sul state, Brazil), where Mr Joaquim worked as a cowboy. He was around 65 years old, and the farmer did not expect that he would be able to adapt to the new way of work, but he succeeded. After three months of training he was interviewed and asked his opinion about the adoption of good handling practices. His answer was:

Before, at the end of the day, I used to go home very tired, going straight to bed just after a shower and dinner. Usually, I used to sleep thinking of the next day's work, which would be started very early, at six



Fig. 10.2. A lead horse is used to calmly bring Nellore cows into the corrals. (Photo: Temple Grandin)

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in the morning. Today it is different; I go home, and after a shower and dinner, I still have energy to watch TV and to talk with my wife.

A similar report was collected during a practical course in the north of Uruguay, where a cowboy asked for an opportunity to express his feelings and experiences about cattle handling (he had attended a previous course); he picked up the microphone and said to his colleagues: 'In the past I used to be very nervous and displeased after everyday working with cattle, and now I feel more relaxed and less tired after working with them.' It was clear that the man was proud of his work, which is not so common among livestock people working in the old traditional way. Both of the statements above summarize the importance of adopting improved cattle handling practices: they have positive effects on animal welfare and also provide a better quality of life for the livestock people.

The Benefits of Good Stockmanship on Cow-Calf Farms

The Brazilian research group has published many studies since the previous edition of this book in 2014. Two studies by Ceballos *et al.* (2018a,b) clearly show the importance of good practices. Never miss

the opportunity to promote positive interactions with animals. Trained handlers had a more positive attitude towards the cattle and were less likely to allow handling practices to deteriorate over time (Ceballos et al., 2018a,b). Nellore heifers handled quietly also had the advantage of less defecation (Ceballos et al., 2018b). Cattle that were much less reactive were cleaner, which facilitates artificial insemination. Another study (Rueda et al., 2015) found that excitable Nellore cattle took longer to handle and the cows had higher flight speeds and reduced pregnancy rates. Nellore cattle that are handled frequently for rotational grazing became calmer and less reactive (Ceballos et al., 2016). Animals that are rotated between pastures every four days had lower flight speeds compared to animals rotated every 20 days (Ceballos et al., 2016; Gois et al., 2016). Researchers have also found that Nellore calves maintained for a short period of life (45 days during dry season) in feedlot pens, and after that being moved back to the pasture, were less reactive than those kept all the time on pastures (Vasconcelos et al., 2018). Such experience will probably help the animals to settle down in a feedlot pen later in life.

The more reactive Nellore cattle have lower performance in a feedlot (Bravo *et al.*, 2016). The calmer individuals have better weight gain (Braga



Fig. 10.3. Temple Grandin and a Brazilian cowboy stroke a newborn Nellore calf on Orvalho das Flores ranch, in Brazil. It was found that this method reduced reactivity in piglets (de Oliveira *et al.*, 2015), and improve dairy calves' health (Magalhães Silva *et al.*, 2014). This research will determine if this will be effective for beef cattle. Photo courtesy Temple Grandin no Brasil/Enilson Arneiro.

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et al., 2018). This replicates the findings of research on *Bos taurus* cattle (Voisinet *et al.*, 1997; Petherick *et al.* (2002).

Stroking young calves

Paranhos da Costa and his research group are also conducting research on stroking newborn Nellore calves. This is a gentle version of the foal imprinting method. It needs to be emphasized that it is done gently. Some foal imprinting methods have been very rough. It will be interesting to determine if this produces a calmer adult animal (Fig. 10.5). A similar treatment on non-weaned piglets reduced fearfulness when they matured (De Oliveira *et al.*, 2015).

Low-stress weaning

Cow-stress weaning should be carried out when the calves are eight months of age. The calves should be kept close to their mothers for at least three days after separation. Either fence-line or across-the-road weaning is used (Fig. 10.4).

Low-cost Corral Layout

There is still a need for further developments of facility design for small producers, who usually do not have the financial resources for big investments. One initiative in Brazil (see Paranhos da Costa and Quintiliano, n.d.) is the recommendation on how to build a low-cost cattle corral. In summary, the authors discussed the necessity of putting aside the idea that the corrals must have a large capacity for cattle 'storage' and that they should always be built to withstand extreme pressure (exerted by cattle) by using heavy materials. This change in concept must be adopted after the implementation of good handling practices in the corral, taking into account the behaviour and welfare of people and animals to define the day-to-day work on the farm. Calm cattle are easy to handle and, because of that, there is no need for strong structures to manage them. As an example, an architectonic design for a low-cost corral is presented in Fig. 10.5., while Fig. 10.6 illustrates the use of bamboo as an alternative material to build the solid shields in the areas of intensive handling.



Fig. 10.4. Fence line low-stress weaning across a road of Nellore cows and calves at Orvalho das Flores ranch in Brazil. Both the cows and calves remained silent with no pacing or bellowing. (Photo: Temple Grandin)

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Fig. 10.5. An example of an architectonic design for a low-cost corral. The thick black lines represent solid shields (combining wire or wood fences with bamboo) and the thin black lines represent wire fences. Similarly, wood gates with a solid shield are represented by a thick black (opening) line, and (plain) wood gates by a thin black (opening) line. The cross-hatched area is a catwalk that runs alongside the race. A handler with a flag standing on this catwalk can easily move the cattle from the crowd pan into the race. The design is by Paranhos da Costa and Quintiliano (undated).



Fig. 10.6. A–D. Examples of solid shields built economically with bamboo on a wire or wood plank fence. This type of fencing is used on the fences marked with heavy black lines in Fig. 10.5.

Genetics and Nellore Behaviour

Valente *et al.* (2016, 2017) and Sant'Anna *et al.* (2013, 2015) found that temperament traits in Nellore cattle are moderately heritable. Temperament is a complex trait which is influenced by both the environment and genetics. A genome-wide association study has been conducted on Nellore (Valente *et al.*, 2016). They identified nine genome regions associated with the results of the exit speed test.

Some others interesting Brazilian research: crossbred Girolando cows (1/2 Holstein x 1/2 Gyr, and 3/4 Holstein x 1/4 Gyr) show that the calf protection behaviour and reactivity during milking are separate traits (Soares *et al.*, 2018); in the Canchin breed of cattle (a cross between Charolais and *Bos indicus*), the more reactive cattle had a smaller cannon bone (Ribeiro *et al.*, 2018). These results are similar to a study done by Lanier and Grandin (2002); and sometimes the genetic background of the cattle will have unexpected effects. When flight speed was measured, Caracu cattle exited more slowly from the squeeze chute but they had higher cortisol levels than more reactive cattle, such as Nellore (Miranda *et al.*, 2018).

Research Update from Uruguay on Bruises, Pasture Systems and Truck Design

The OIE recognizes the important role played by all the various stakeholders in changing perceptions of

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animal welfare, by raising public awareness and promoting communication and co-operation as drivers of overall change in the Americas (Huertas *et al.*, 2014).

Recognizing that transport is one of the most stressful interventions, the training of animal handlers and transporters was emphasized, showing them the consequences of inadequate handling with audiovisual material prepared on site. Research results have helped to develop new legislation or to make changes in the existing legislation related to animal welfare (Gallo and Huertas, 2015). Replacement of sticks and electric prods with flags during truck loading reduced carcass bruises (Huertas *et al.*, 2018a).

Despite great efforts made in recent years along the supply chain, it was a disappointment to observe the recent increase in the prevalence of carcass bruises reported in the third Uruguayan quality audit of beef (INIA, 2017). Strappini *et al.* (2012b) found a 'slight' agreement among observers for the number of bruises scored per anatomical site. Possibly INIA (2017) overestimated bruising. Although, the audits tried to use the same procedure, the observers were not the same and the training may not have been sufficient.

However, it should be taken into account that in different studies conducted in Uruguay, no bruises of grade 3 were found. Grade 3 bruises involve muscles and bones (Crosi *et al.*, 2015; Gibernau *et al.*, 2018). Also Strappini *et al.* (2012b) found a 'fair' agreement for the degree of bruises severity. The fact that there are no bruises of grade 3 could indicate that although there is much work to be done, at least there seems to be more awareness about the welfare of the animals along the chain.

Reduction in Electric Prod and Stick Use

A survey performed in 2016 in Uruguay showed that 70% of the veterinarians who work in the field with production animals had attended at least one animal welfare (AW) course. They also stated that 25% of the farms they visited had knowledge related to AW and properly implemented good animal handling practices. Although the use of flags increased to 77% according to veterinarians, the use of electric prod and sticks was still high (more than 40%) and more than one was used (Laport *et al.*, 2017).

A study peformed in the country showed that in 40% of the loadings a flag was used but also other non-recommended devices to move animals, while

in the total of the unloading in the slaughterhouses, only flags were used (Huertas *et al.*, 2018a).

This is a continuous improvement, so let's continue insisting on maintaining high welfare standards, raising awareness throughout the chain and, if possible, applying economic penalties.

Initiatives to Promote the Welfare of Animals on Farms

Animal production systems that combine trees or shrubs with pasture are considered silvopastoral systems (SPS). These systems have the potential to improve animal productivity, increasing the biological and economic efficiency of livestock farms while contributing to the ecological sustainability of these systems (Broom *et al.*, 2013).

This integration between grass and trees seems to be beneficial, providing shade, shelter, food and water permanently to animals, which all contribute to the animal's welfare. This situation constitutes a valid alternative to conventional farming in many Latin American countries (Calle *et al.*, 2012; Broom *et al.*, 2013).

Despite having several types of SPS, these systems seem to have in common a beneficial impact on the welfare and productive performance of beef cattle, but most of the results so far are obtained from tropical regions and with *Bos taurus indicus* breeds (Ibrahim *et al.*, 2010; Molina *et al.*, 2008; Murgueitio *et al.*, 2011).

Aiming to clarify the existence of these benefits in temperate regions such as Uruguay, where European breeds are more common, research was conducted on extensive beef farms. Beef cattle were placed on either SPS or Natural Grassland (NG), to compare animal health, welfare indicators and bodyweight (BW) during 2015 and 2016. In Uruguay, almost all forestry enterprises use *Eucalyptus* spp. and fewer *Pinus* spp. Most producers, traditionally farmers, let animals graze within the paddocks with trees, with the perception that this is relatively profitable (Sanz *et al.*, 2007).

Preliminary results showed no differences for good health indicators such as injuries, lameness or integument alterations (hairless patches and lesions/ swellings); signs of disease such as nasal discharge, ocular discharge, hampered respiration and diarrhea (Huertas *et al.*, 2017).

Significant differences were found between farms and visits for bodyweight (p < 0.01), but no differences were found between treatments (p = 0.176).

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The weight of animals in SPS seems to have less variability compared to those in NG. This study illustrates that well-managed farms have more productive cattle. Also, farmers can benefit from the additional income generated by the wood production yet maintaining their traditional cattle farming lifestyle.

Environmental conditions

Advantages of some mixed-production models like silvopastoral systems, which integrate forestry plantations with extensive beef production, have become common with the potential to increase the productivity per hectare (Broom *et al.*, 2013).

Preliminary results of researches performed in Uruguay showed that during the summertime, temperature and humidity index (THI) was higher in SPS than in NG, in some cases reaching alert levels; however, no heat-stress behaviour was observed in the animals, while in winter there were no differences, either THI or in animal behaviour (Huertas *et al.*, 2018b).

The animals in SPS dedicated more time grazing in summer than the animals in NG systems. The reduction of sun radiation in the SPS could account for this. In SPS, the effective grazing surface is smaller than NG due to the presence of the trees, yet no significant differences were found in animal performance in both groups; however, animals in SPS showed less variation in bodyweight during the study period. The botanical species diversity index was higher in SPS in comparison with NG (1.69 and 1.55, respectively), but in both systems botanical species of agronomic interest and of a great adaptability were presented and quantified (Huertas *et al.*, 2018b).

Initiatives to Promote the Welfare of Animals during Transport in South America

There are two aspects to consider that can affect the welfare of transported animals: the knowledge and commitment of truck drivers and the quality of the vehicles. The design of vehicles, their materials, condition and improper handling during loading and unloading can cause traumatic lesions (bruises) of different degrees of depth and location in the carcass. This fact, besides showing welfare deterioration, is the cause of great economic losses (Huertas *et al.*, 2015). To compare the current reality with that of the last decade, different surveys based on protocols already developed (Huertas *et al.*, 2010, 2015) related to animal-welfare knowledge of truck drivers and the characteristics of cattle transport and its relationship with animal welfare were performed in Uruguay. Results revealed that of almost 300 truck drivers surveyed, 80% declared that they received training. However, the use of the electric cattle prod is still around 50% in loading and unloading at slaughterhouses. Flags were used in less than 35% (Gibernau *et al.*, 2018; Huertas et al., 2018a).

Over the years, the fleet of vehicles to transport livestock has been changing and possibly affects the welfare of animals. The average year of the vehicles is 2008 (ranging between 2005 and 2015). The materials most used for the construction of the vehicles are aluminum (12.5%) and steel (87.5%). All of the trucks had a guillotine-type door (Huertas *et al.*, 2015).

The frequency of different types of trucks in 2017 were: 60% articulated truck with three axles and one deck; 20% articulated truck with five axles and two decks; 12.5% articulated truck with double trailers; and 7.5% non-articulated truck with three axles (Gibernau *et al.*, 2018). Note that the double-deck truck is relatively new in Uruguay. However, some rough roads may not be appropriate for this type of vehicle, which could cause more problems for the animals. More research is needed.

From a total of 10,400 transported animals, the average prevalence of carcass bruises was 60%. An average of 33% had a bruise in one single zone, 26% in two zones, 15% in three and 26% in four or more zones. Regarding the depth, an average of 82% of the lesions were grade 1 (superficial, generally removed by carcass dressing); 27% were grade 2 (medium, with some muscle involved); and 0% were grade 3 (the deepest). The most frequent zones affected were the coxofemoral joint (29.3%), back zone (19.6%) and rib cage (15.7%) (Crosi et al., 2015; Huertas et al., 2018a; Gibernau et al., 2018). These results are in line with the latest findings in the quality audit performed by the Meat Institute of Uruguay (INAC, 2017), where no bruises of this degree of severity were observed.

Although grade 3 bruises did not appear, indicating that probably animal handling has improved, the total percentage of injuries remains high. It is necessary to continue with training courses for personnel, the proper maintenance of facilities and ensuring that good vehicles are employed.

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A system for livestock protection during transport: PROGAT

Bruises in beef cattle during loading, transport and unloading manoeuvres are of great relevance, causing animal suffering and great economic losses to the entire sector (Huertas *et al.*, 2015). Although, the average distance of transport is 240 km in 5 hours, the prevalence of bruises reaches 60%. There were no mechanisms in the country or in the world that contribute to protect animals from possible impacts against the sharp edges of vehicles during loading, transport and unloading.

With the aim of providing a solution to this global problem, and applying the knowledge of the automotive and metal-mechanic industry, a device was designed and constructed that consists of an elastic strip placed inside the trailer of a truck and steel paddles that act as a 'funnel' that are pneumatically activated to cover the door frames, both inside the cage and in the main door (Figs 10.6 and 10.7). The system is operated by the truck driver and easily washable with water under pressure.

The device was tested for statistical validation, comparing 19 pairs of identical trucks (brand, model, year, maintenance) with similar cattle for slaughter. One vehicle carried the device and another did not. Both vehicles started from the same farm, on the same day and time and followed the same route, arriving together to the same slaughter house. Trained observers recorded the loading and unloading of 1177 animals and, after slaughter, the presence of bruises, their location and depth (Huertas *et al.*, 2010).

The results showed that animals transported in a truck with the PROGAT device had a significantly lower proportion of bruises (p < 0.001) than those in the conventional vehicle (Huertas *et al.*, 2018c). A small proportion of bruises was observed in the rump area (where are situated the cuts of greatest commercial value) as well as in the ribs and on the shoulder. No degree 3 bruises were recorded in the



Fig. 10.7. Pneumatically operated PROGAT device that closes the gap between the loading ramp and the back of the trailer (Huertas *et al.*, 2018c) after the trailer is loaded the air cylinder retracts the flap. (Photo: Temple Grandin)

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Fig. 10.8. The rounded surface of the PROGAT device helps prevent bruises from cattle striking the centre divider (Huertas *et al.*, 2018c). (Photo: Temple Grandin)

vehicle with PROGAT. The data showed that animals transported in a conventional vehicle were 1.6 times more likely to show at least one bruise (p < 0.001). It is concluded that the PROGAT device installed in a vehicle transporting cattle constitutes a protection against bruises.

Articulated lorries are becoming more common in both Brazil and Uruguay. Figure 10.8 shows a new double-deck lorry for cattle. It has a deck that can be raised and lowered.

Welfare of Weaner Calves and Culled Cows during Transport and Marketing in Chile

Carmen Gallo's Research Group in Chile has conducted new studies on weaner transport. Selling cattle through livestock markets is still common in many South American countries (Gallo and Tadich, 2008; Gallo and Huertas, 2015). This is an inherently stressful process, because animals are taken away from their environment, loaded, unloaded and transported more than once. They are kept confined in an unknown environment; hence time off for food and water (fasting) increases. At livestock markets animals are handled by either unknown or untrained handlers. The animals are exposed to at least twice as many physical and psychological stressors compared to calves sold directly from farm to farm (Gregory, 2008).

De Vries (2011) studied the human-animal relationship (HAR) in 40 stockpersons at the Chilean livestock markets. The results revealed that some characteristics of the market design were associated with a negative HAR, the occurrence of narrow entrances, dark structures and dirty or wet floors being the main points of concern. These factors hinder animal movement and induce the use of unwanted driving aids, like the stick, by stockpersons. Most of the stockpersons (65%) observed had a negative HAR. Since 2013 (Chile, 2013a) it is compulsory by law that stockpersons at farms and livestock markets go through a training course in animal handling and there has been some improvement. However, some forbidden and bad handling practices can be still observed and there is need for better enforcement of the law.

The negative effects of passing through cattle markets have been evidenced on the carcasses of steers and cows; the presence of bruises with tram-line appearance, characteristic of those caused by sticks, were reported frequently (Strappini *et al.*, 2012a). The high number of bruises found in cows sourced from markets can be associated with the quality of the HAR in Chilean markets (De Vries, 2011) as well as with the fact that animals going through markets are exposed to at least twice as many handlings.

The short- and long-term effects of transport and fasting on welfare and production have not attracted so much attention in calves as in cattle ready for slaughter, and are more difficult to measure. In Chile, around one million cattle go through livestock markets annually, and over 30% of them are calves, this being the main category sold. Another large category commercialized at these premises is the 'cow'.

Transport and marketing of weaner calves

Recently, the transport of weaned calves (150–250 kg live weight) to 20 Chilean livestock markets was described through a survey applied to 287 transporters at 20 livestock markets by Bravo *et al.* (2018a). Eighty per cent of the transporters had been trained as animal handlers during transport, which is in line with the new regulations which make this training compulsory in Chile in order to increase the competence of drivers (Chile, 2013b).

According to Bravo et al. (2018a) the mean transport time from origin (farm) to the market was only 75 minutes (although it ranged between 5 minutes and 13 hours), and from the market to destiny (usually another farm where calves are fattened) only 45 minutes (5 min - 40.5 h); however, including the time spent in the market pens (without food and water), calves completed at least 12 hours fasting, and frequently up to 24 hours. In 36% of all loads it was observed that calves were mixed with cattle from other categories and in 5% of the cases they were even mixed with other species. Space availability was 0.91 m² per calf and the most frequently used bedding material was sawdust (60%), followed by sand/earth (12%) and rubber flooring (11%). There was absence of bedding material in 9% of the loads.

Loading animals onto livestock vehicles is one of the most stressful processes associated to transport (María *et al.*, 2004). Quantifying the frequency of behavioural events associated with handling during loading and unloading can provide objective measures of welfare at livestock markets. Weaned calves brought to 20 livestock markets were observed during unloading at arrival to the market (n=1252), and during loading after the sale (n=1344). Infrastructure for unloading/loading cattle was considered, in general, adequate (non-slippery floor, slope $\leq 25\%$ and lateral protections). Personnel handling the animals were transporters themselves and also people hired by the market; the main driving aids used by them were wooden sticks and plastic pipes, whereas flags were rarely observed. Electric goads were only used in 12% of loadings, as shown in Table 10.1. Improper handlings like hitting and pricking were much more common during loading than unloading in calves as well as in cows (Bravo et al., 2018b; Sánchez et al., 2018b).

Short-distance transport and fasting of weaner calves

In order to determine the possible welfare consequences for calves of going through the cattle markets, we studied the effects of a short transport and a total of 24 hours' food and water deprivation on live weight, some blood variables related to stress, maximum eye temperature (MET) measured using infrared thermography, and tympanic temperature (TT) (Bravo et al., 2018c). Ten Angus calves of 146.1 ±19.1 kg live weight were transported for three hours at a space allowance of 1 m² per 270 kg. Maximum eye temperature (MET) was obtained with a thermographic infrared camera (FLIR i5, FLIR Systems, Wilsonville, Oregon) and temperature (°C) was adjusted according to environmental t° and humidity. To register tympanic temperature (TT°), i-buttons (Maxim Integrated Products Inc., California) were fitted into the calves' ears before loading. MET, TT, live weight, cortisol, glucose, CK, haptoglobin and betahydroxybutirate were measured in blood samples before loading, after unloading and after completing 24 hours fasting in pens (no water, no food) to simulate the conditions during commercialization of calves through livestock markets. Statistical analysis was done using a linear mixed model (time as a fixed effect and the individuals as random effect). Fifty per cent of the total live weight loss occurred during the 3 hours of transport, whereas the other 50% occurred during the period the calves were fasting in the pen (Table 10.1). The significant increase in betahydroxybutirate after 24 hours fasting (with transport included) indicates

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Behavioural events	CALVES		CULLED COWS	
	Unloading (n = 1252)	Loading (n = 1344)	Unloading (n = 1011)	Loading (n =484
Falling	1.7	1.4	5.6	2.7
Slipping	11.7	4.7	14.5	11.2
Jumping	6	4.2	1.4	0.4
Going back	0.2	5.7	0.5	14
Balking	2.8	3.7	7.3	7.2
Vocalizing	7.3	0.4	2.9	1
Mounting	2.4	1.8	0.2	0
Agressions	0.2	0.1	0	0
Defecating	0.3	0.8	1.4	2.1
Handling events				
Hitting	3	46.1	11.2	52.5
Pricking	6.8	72.3	12.1	54.8
Kicking	2.2	2.4	2.3	0
Tail twitching	0.1	0.5	0	0

Table 10.1. Behavioural events of calves and culled cows, and handling events observed during unloading and loading at 20 cattle markets in Chile.

Table 10.2. Means and standard deviations of variables measured before loading (T1), after 3 hours' transport (T2) and after completing 24 hours of food and water deprivation (T3) in weaned calves.

Variables	T1	T2	Т3
Live weight (kg)	146.1 (± 19.1)a	141.1 (± 18.6)b	136.1 (± 18.5)c
Timpanic T° (°C)	37.15(± 0.6)a	37.7 (± 0.37)b	_
Maximum eye T° (°C)	34.72(± 0.70)a	36.30 (± 0.52)b	34.48 (± 0.59)a
Cortisol (µg/dL)	1.55 (± 1.1)a	2.28 (± 1.1)a	2.29 (± 1.1)a
Glucose (mmol/L)	3.68 (± 0.33)a	4.38 (± 0.43)b	3.97 (± 0.32)c
β-HB (mmol/L)	0.26 (± 0.07)a	0.22 (± 0.09)a	0.35 (± 0.12)b
Creatin Kinase (U/L)	242.9 (± 59.7)a	398.4(± 147.4)b	189.3(± 49)a
Haptoglobin (mg/ml)	0.16(± 0.04)a	0.15(± 0.02)a	0.26(± 0.21)a

that, even with this short time, the calves had to make use of their body reserves. Cortisol and haptoglobin did not change significantly during the 3 hours of transport (p > 0.05). G, CK, TT° and MET increased after transport (p < 0.05) and returned to initial values during fasting in pens. No correlation was found between MET and blood variables; however, a moderate correlation was found between MET and TT (r = 0.5288). The increase in MET and TT° could reflect body increase due to stress and physical exercise during transport.

It was concluded that even in this controlled replication of the marketing process, where calves were handled calmly, without being mixed with unfamiliar animals or exposed to unfamiliar environment, there was a significant effect of the transport and fasting on the calves, which was measurable through MET, TT, blood indicators such as CK, glucose, betahydroxybutyrate and live weight. The live weight loss is economically important because calves are traded based on their live weight at the livestock markets (Bravo *et al.*, 2018c).

Long-distance Transport and Fasting of Weaner Calves

In Chile, prolonged transport of cattle, particularly weaned calves, is still an important issue due to geographical conditions and the fact that calves are bred on some farms and fattened elsewhere. One of the regions producing calves is Aysén, in the Chilean Patagonia, and they have to be transported

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in trucks on ships (roll-on roll-off). Bodyweight losses and long recovery times add economic losses to the producers, and certainly have an impact on the welfare of the calves due to the long transportation journeys (Gallo, 2008).

Werner et al. (2013) described the bodyweight changes and some blood constituents related with stress response after a 63 hours transport of recently weaned calves (approx. 240 kg) in the Chilean Patagonia. The high cortisol concentration values found before transport (P < 0.05) suggest that the handling process prior to transport (herding from distant fields, regrouping in pens before loading and weaning) which are common practice in extensive systems in the Patagonia, was already stressful for the calves, being that this mean cortisol value was the highest throughout sampling stages (Table 10.3). Similar results, showing highest cortisol levels before loading, have been reported in lambs produced, handled and transported under similar conditions in the Chilean Patagonia (Tadich et al., 2009).

The significant bodyweight loss of calves during long-distance transport, reaching 14% after the 63 hours journey (Werner et al., 2013), is consistent with the high betahydroxibutyrate concentration found after transport. This indicates that food reserve depletion represents an important factor for young animals transported this long, and that the weight lost was not only gutfill. This, besides affecting animal welfare, adds long-term economic losses to the producers. In fact, a live weight recovery period of four weeks was found by Werner et al. (2013), and it is probably related to the fact that after transport the calves ate and drank less than required in the new environment and hence continued mobilizing body reserves until the third week after transport (Table 10.3). This is consistent with the findings of Knowles (1999).

As transport duration cannot be shortened due to the typical Chilean geography in the Patagonian region and the scarcity of proper routes, conditions of transported calves should be improved by using specialized livestock vehicles that can provide more comfort, as well as access to water and food during the journey. Feeding and providing access to water during journeys longer than 24 hours has become compulsory since October 2013 in Chile (Chile, 2013b). However, this also means that space allowance must be increased, so that animals have the possibility to have access to food and water provided, and also to lie down. Navarro (2018) compared one of these journeys with calves (240 kg live weight) a low space allowance (0.66 m²/head) and a 30% higher space allowance (0.86 m²/head), and found that the extra space increased the time that animals spent lying down, standing up, eating and ruminating, all considered important activities for animal welfare during long-distance transport. Even though in this study the animals were fed with a bale of fodder twice a day per pen, this was apparently insufficient to satisfy their metabolic demands, because the calves had an increased blood concentration of betahydroxybutyrate and a decrease in glucose concentration after unloading; the CK value was also increased after unloading (949 U/L) indicating physical demands during the trip.

Negative Effects of Prolonged Fasting of Steers before Slaughter

A negative effect of prolonged fasting times (due to transport and/or lairage) on meat quality has been described earlier by several South American authors in cattle at slaughter (Amtmann *et al.*, 2006; Gallo *et al.*, 2003; Romero *et al.*, 2013). Fasting is an important practical issue in regions where steers undergo long-distance transport to slaughter plants, pass through livestock markets or have long lairage periods at the slaughterhouses, as is still the case in Chile and other South American countries (Gallo, 2016a,b; Gallo and Huertas, 2016).

In fattening steers (340 kg live weight) fasting for 24 hours reduces by 22–27% the glycogen content in muscle, as verified through muscular biopsies of the *Longissimus lumborum* muscle (Apaoblaza and Gallo, 2014). In steers ready for slaughter, no fasting helps maintain a higher muscle glycogen content and higher glycolytic potential; no fasting was also found to help in increasing glycogen debranching enzyme (GDE) activity post mortem (Apaoblaza *et al.*, 2017).

Although in many countries there are now regulations regarding transport and slaughter of livestock (Gallo and Tadich, 2008), fasting times remain long in many South American countries for diverse reasons. At a slaughterhouse in Colombia, we observed 99 trucks arriving with 336 cattle with a mean transport journey of 15.5 hours, and cattle had to wait a mean of 6 hours on the truck between arrival at the slaughter plant and unloading (Ramírez and Gallo 2012; Romero *et al.*, 2013). This happens in Colombia because loaded cattle trucks arrive at night and dawn, and stockpersons arrive at 7 am to start unloading. In the case of Chile, unloading of cattle occurs usually within 20 minutes of arrival at

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the slaughterhouse. However, in Chile cattle are kept in lairage usually for over 12 hours, because they are brought from the farms the evening or night before the expected slaughter; moreover, this time without food is increased by passing often through a livestock market before that or by long-distance transport. These facts and the fattening system based mainly on pasture affect the concentration of glycogen before slaughter increasing the risk for high pH (Apaoblaza *et al.*, 2017. Reducing fasting times due to transport and lairage at markets and slaughterhouses is a low-cost and easily modifiable variable, but it requires a well-planned transportation and slaughter schedule, worked out between farmers and slaughterhouses.

Transport and Welfare of Culled Cows Passing through Markets

Sánchez *et al.* (2018a) evaluated the welfare status of 1495 culled cows at 15 cattle markets in Chile in terms of their health and body condition, finding that 45% of them had a low body condition (Welfare Quality[®] = 1); 30% were lame; 21.3% had mammary problems; 4.2% had other lesions (skin lesions, eye carcinoma, fractured tail or legs); 3% were pregnant at visual appraisal; 15.2% arrived with their calves and were weaned at the market. The low body condition and bad health status of the culled cows passing through the cattle markets reflect that their welfare is already compromised when leaving the farms. The delay in culling until the economically optimal time can also carry a welfare cost.

Lameness and mastitis have been recognized as important culling causes and both health problems are linked to welfare due to the pain they cause, hence cows transported to livestock markets are at great risk of experiencing stress and poor welfare. From an animal welfare perspective, it is extremely important to handle weak cows, particularly those with mastitis and lameness, carefully, because these animals will be in pain and distress, and this condition will follow or even aggravate during marketing, transport and slaughter (Gallo and Strappini, 2017). These animals should not go through auction markets, and special conditions should be offered to them during transport (more space availability, bedding etc.) in order to avoid further detrimental conditions during this period. Transporting these cows directly to slaughterhouses instead of selling them through cattle markets could improve their welfare.

Transport time for cows from the farm to the livestock market was found to be 1.23 hours, and from the market to destination was 2.26 hours. After the sale, 46% of the culled cows were transported back to farms and 54% to a slaughterhouse. Based on these observations, a mean time without food and water for cows passing through livestock markets was estimated to be 12.32 hours including transport and the time spent in the market pens (Sánchez *et al.*, 2018b).

Culled cows (n = 1425 at 15 livestock markets) were observed during unloading at arrival at the livestock market and at loading after sale (Sánchez *et al.*, 2018b). Handling and behavioural events were registered as shown in Table 10.2 (Bravo *et al.*, 2018b). The means of the frequencies of handling and behavioural events in cows were registered, as shown in Table 10.1. Comparatively, culled cows showed more behavioural events like falling, slipping, balking and defecating, whereas weaned calves jumped and vocalized more during loading and unloading.

All behavioural events observed in the cows, besides vocalizations, were higher than acceptable, according to Grandin (2010); hitting and pricking cows was significantly higher during loading than unloading, and forbidden actions like kicking were still observed. According to these results, the handling of culled cows at cattle markets further compromises their welfare and it is necessary to take corrective action like training stockpersons at the market and reducing time spent at the premises.

Space requirements for cattle during transport

The OIE (2018) standard for the transport of animals by land indicates that the space required on a vehicle or in a container depends upon whether or not the animals need to lie down or stand. When they lie down they should be able to adopt a normal lying posture and when they are standing they should have enough space to adopt a balanced position. The Chilean regulation for transport, however, has adopted some standards from other regulations, without considering space recommendations according to the needs of the types of cattle we produce – mainly dual-purpose breeds with black–and- white, as well as red, Holstein and Friesian crosses.

Tabilo and Gallo (2016) measured the space anatomically occupied by 26 typical dual-purpose cattle of different ages and live weights (between 45 and 642 kg), using a dorsal view through temporized

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cameras placed at a defined height, every five minutes for 24 hours in pens, and obtained photographs of the animals in three positions: standing, sternal recumbency and sleeping (Fig. 10.9). A onemetre yellow line was painted on the back of each animal and photographs were ruled in squares according to this standard using the AutoCAD 2014 program. The squares were measured and counted with the Paint Microsoft Windows version 6.1 to obtain the area occupied by the animal's body in each position (Fig. 10.10) and a regression equation was established between weight and area occupied. When results for the standing position were compared to an equation that uses the minimum permitted space allowance in Chile, which is also the most common space allowance used commercially (1 m² for 500 kg; Gallo *et al.*, 2005), it was found that the standing space allowance for smaller cattle is being underestimated, whereas for adult cattle it is overestimated (Fig. 10.11). However, when using the formulae recommended by international authors (Fig. 10.12), our results for standing animals definitely underestimated the space requirements because they do not include the space necessary for animals



Fig. 10.9. Double deck articulated cattle lorry that is used in Brazil. It has a deck that can be raised up and down that eliminates internal ramps. Brazil allows taller vehicles than North America or Europe. Photo Courtesy of Temple Grandin



Fig. 10.10. Photographs of a 93 kg live weight calf in the three positions that were photographed. A: Standing, B: Sternal recumbency, C: Sleeping. Yellow line painted on the calf's loin as a reference standard for 1 m length to further rule in squares. When the calf is lying down, much more space is required. (Photo: Barbara Tabilo)

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Fig. 10.11. A: Image of 642 kg live weight cow stand; B: Same image rule in squares; C: Image coloured for counting and measuring the squares. In images A and B, the reference standard for 1 m length is painted as a yellow line for square ruling. (Photo: Carmen Gallo)



Fig. 10.12. Regression lines obtained for space occupied by cattle of different live weights in the standing position and for minimum space allowed according to the Chilean transport regulations. (From Tabilo and Gallo, 2016)

to keep their balance during transport, in addition to the space occupied by the standing animal. This study allowed us to provide a formula to objectively define the space requirements for the common dual-purpose breeds used in Chile and for different categories of cattle for transport. More research is needed in order to relate the behaviour of cattle of different ages and weights during transport with the space required, particularly considering shortversus long-distance transport. The minimum space required for animals should be based on dimensions and activities during transport (Randall, 1993).

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